PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2001-244514

(43)Date of publication of application : 07.09.2001

(51)Int.Cl. H01L 41/083
F02M 51/06
H01L 41/09
H02N 2/00

(21)Application number : 2000-054849

(22)Date of filing : 29.02.2000

(71)Applicant : KYOCERA CORP

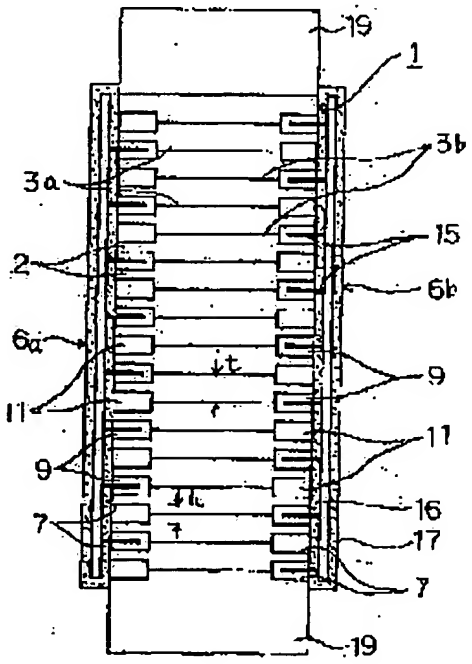
(72)Inventor : ASHIDA KOKI

(54) LAMINATED PIEZOELECTRIC ACTUATOR AND INJECTOR USING THE SAME

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a laminated piezoelectric actuator and an injector with high reliability that can sufficiently ensure connection between an internal electrode and an external electrode even in the case of a high-speed continuous operation over an extended period in a highly applied electric field.

SOLUTION: There are provided: an actuator body 1 in which piezoelectric bodies 2 and internal electrodes 3a and 3b are stacked alternately, and a pair of external electrodes 6a and 6b which are disposed on different sides of the actuator body 1 and electrically connect the first internal electrodes 3a and the second internal electrodes 3b, respectively. Concave grooves 7, on which the ends of a plurality of internal electrodes 3a and 3b are exposed, are formed on the sides of the actuator body 1 having the external electrodes 6a and 6b formed thereon, respectively. Conductors 9 and insulators 11 are alternately fill the concave grooves 7. Further, an end of a connecting conductive member 15, which has the other end embedded into the conductor 9, is connected to the external electrode 6a or 6b.



LEGAL STATUS

[Date of request for examination]

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's decision of rejection]

[Date of requesting appeal against examiner's decision of rejection]

[Date of extinction of right]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the laminating mold electrostrictive actuator and fuel injection equipment which are used for precision positioning devices, such as an automotive fuel injection valve and optical equipment, the driver element for vibration isolation, etc. with respect to the fuel injection equipment which used a laminating mold electrostrictive actuator and this.
[0002]
[Description of the Prior Art] In order to obtain the big amount of displacement conventionally using an electrostrictive effect, the laminating mold electrostrictive actuator which carried out the laminating of a piezo electric crystal and the internal electrode by turns is proposed. When it is classified into two kinds of veneer laminating types which carried out the laminating of a coincidence baking type, piezoelectric ceramics, and the internal electrode plate by turns and takes into consideration in a laminating mold electrostrictive actuator from the field of low-battery-izing and manufacture cost reduction, since it is advantageous, a coincidence baking type laminating mold electrostrictive actuator is showing the predominance to it to lamination.
[0003] The insulating layer which becomes setting further at the edge of the internal electrode exposed to the side face of the body of an actuator from glass is covered, to an external electrode, the edge of the internal electrode with which the insulating layer is not formed between these insulating layers is covered with the electrically-conductive-glass film, and the electrically connected laminating mold electrostrictive actuator is indicated as indicated by JP,6-66484,B as a coincidence baking type laminating mold electrostrictive actuator.
[0004] however, in the laminating mold electrostrictive actuator indicated by JP,6-66484,B Although the insulating layer which becomes setting further in the edge of the internal electrode exposed to the side face of the body of an actuator from glass is covered, the piezo electric crystal of the both sides is firmly joined to the internal electrode and the insulation of an external electrode and an internal electrode is secured When a prolonged continuation drive was carried out, the crack arose on the electrically-conductive-glass film, exfoliation arose between the internal electrode and the external electrode through this crack, the electrical potential difference was no longer supplied to some piezo electric crystals, and there was a problem that a displacement property changed during a drive.
[0005] Moreover, in such an actuator, since lead wire was formed in the external electrode by soldering, the electrically-conductive-glass film currently used for an external electrode produced the solder foods crack, and there was a problem on which the dependability of a flow is reduced remarkably.
[0006] As opposed to such a problem in JP,63-153870,A In order to prevent exfoliation of an external electrode and an internal electrode and to raise the dependability of the flow between lead wire, an external electrode, and an internal electrode, The insulating layer which becomes setting further at the edge of the internal electrode exposed to the side face of the body of an actuator from glass is covered. To an external electrode The laminating mold electrostrictive actuator which pasted up the edge of the internal electrode with which the insulating layer is not formed in the heights between crevices as it is

the same pitch as an insulating layer, and a little larger crevice than the cross section of an insulating layer is formed and an insulating layer is held in this crevice with electroconductive glue is indicated.
[0007] Moreover, in JP,10-229227,A, a basic metal coat is covered on the side face of a multilayer piezoelectric transducer, the three-dimensional-structure-ized conductive electrode is combined through this basic metal coat and a partial contact part, and the laminating mold electrostrictive actuator in which said three-dimensional-structure-ized conductive electrode was formed in the extensible condition in the contact part is indicated.
[0008]
[Problem(s) to be Solved by the Invention] Although higher electric field are impressed and carrying out a prolonged continuation drive is performed in recent years in order to secure the big amount of displacement in the bottom of a big pressure by the small electrostrictive actuator When a prolonged continuation drive is carried out under high electric field and the high-pressure force In the laminating mold electrostrictive actuator indicated by JP,63-153870,A, exfoliation occurred between the internal electrode formed between piezo electric crystals, and a positive electrode and the external electrode for negative electrodes, and there was a problem that electrical-potential-difference supply would not be carried out and a displacement property changed to some piezo electric crystals during a drive.
[0009] Moreover, even if it was the actuator indicated by JP,10-229227,A, when exfoliation arose in the interface between a basic metal coat and a piezo electric crystal and the exfoliation advanced, the defective continuity of an internal electrode and an external electrode was produced, and there was a problem that electrical-potential-difference supply would not be carried out and a displacement property changed to some piezo electric crystals during a drive.
[0010] This invention aims at offering the reliable laminating mold electrostrictive actuator and reliable fuel injection equipment which can secure connection between an internal electrode and an external electrode enough, even when carrying out prolonged continuation actuation by high impression electric field at high speed.
[0011]
[Means for Solving the Problem] The body of an actuator with which the laminating mold electrostrictive actuator of this invention came to carry out the laminating of two or more piezo electric crystals and two or more internal electrodes by turns, and said internal electrode was used as the 1st internal electrode or the 2nd internal electrode by turns, It is a laminating mold electrostrictive actuator possessing the external electrode of a pair which is prepared in the side face in which these bodies of an actuator differ, and connects electrically said 1st internal electrode and said 2nd internal electrode, respectively. While the edge of two or more of said internal electrodes forms the concave exposed, respectively in the side face of the body of an actuator in which said external electrode is formed It is filled up with a conductor or an insulator by turns in this concave, the end section of a connection conductive member is further laid underground and prepared in said conductor, and it comes to join the other end to said external electrode.
[0012] In this invention, the faulty connection of an internal electrode edge and an external electrode can be prevented by joining firmly the connection conductive member under which the end section was laid, and an external electrode by welding, soldering, etc. to the conductor in the concave formed in the side face of the body of an actuator. It also sets, when carrying out a long-term continuation drive by high impression electric field by this at high speed, and a laminating mold electrostrictive actuator with the high dependability equipped with high endurance can be offered, without exfoliating and disconnecting an external electrode and an internal electrode.
[0013] Moreover, since the conductor in the concave by which the end section of a connection conductive member was formed in the side face of the body of an actuator is laid underground, exfoliation of an external electrode can be prevented according to the anchor effect of a connection conductive member.
[0014] As for a connection conductive member and an external electrode, in this invention, it is desirable to consist of an alloy containing nickel and Fe. Since sufficient reinforcement is maintained to the stress generated by this when stress acted on an external electrode by telescopic motion of an

actuator, the plasmotomy of the external electrode which consists of a metallic thin plate, or a connection conductive member can be controlled, and the laminating mold electrostrictive actuator equipped with high endurance can be offered.

[0015] Moreover, the external electrode consists of a metal mesh or a metallic thin plate, and electroconductive glue that covers these, and it is desirable to join the connection conductive member to a metal mesh or a metallic thin plate. With such a configuration, the stress generated when stress acted on an external electrode by telescopic motion of an electrostrictive actuator can be eased according to deformation of the metallic thin plate of for example, a metal mesh or a corrugated plate configuration, the plasmotomy of an external electrode can be controlled, and the laminating mold electrostrictive actuator equipped with high endurance can be offered.

[0016] Moreover, the fuel injection equipment of this invention comes to provide the stowage container which has a nozzle, the above-mentioned laminating mold electrostrictive actuator held in this stowage container, and the bulb which makes a liquid blow off from said nozzle by the drive of this laminating mold electrostrictive actuator. In such a fuel injection equipment, endurance can be improved based on a laminating mold electrostrictive actuator having high endurance.

[0017]

[Embodiment of the Invention] Drawing 1 is the sectional view of the laminating mold electrostrictive actuator of this invention, and drawing 2 is the sectional view expanding and showing a part of drawing 1 . It is what shows square pole-like the body of an actuator with which a sign 1 comes to carry out the laminating of two or more piezo electric crystals 2 and two or more internal electrodes 3a and 3b by turns in drawing 1 and drawing 2 . 1st external electrode 6a to which 1st internal electrode 3a is connected electrically, and 2nd external electrode 6b to which 2nd internal electrode 3b is connected electrically are formed in two side faces in which this body 1 of an actuator counters.

[0018] Although titanic-acid lead zirconate Pb(Zr, Ti) O3 (it omits Following PZT) or the piezo-electric ceramic ingredient which uses barium titanate BaTiO3 as a principal component is used, as long as a piezo electric crystal 2 is ceramics which is not limited to these and has piezoelectric, any are sufficient as it. As this piezo electric crystal ingredient, what has the piezo-electric high distortion constant d33 is desirable. Moreover, as for the distance of thickness [of a piezo electric crystal 2] t, i.e., internal electrode 3a and internal electrode 3b, it is desirable that it is 0.05-0.2mm from the point of impressing a miniaturization and high electric field.

[0019] In the side face in which the edge had exposed internal electrodes 3a and 3b to all four side faces of the body 1 of an actuator, and 1st external electrode 6a of the body 1 of an actuator was formed Two or more concaves 7 which the edge of all the internal electrodes 3a and 3b exposes, respectively are formed, and the concave 7 which the edge of 2nd internal electrode 3b exposed [the conductor 9] to the concave 7 which the edge of 1st internal electrode 3a exposed is filled up with the insulator 11.

[0020] Moreover, two or more concaves 7 which the edge of all the internal electrodes 3a and 3b exposes, respectively are formed in the side face in which 2nd external electrode 6b of the body 1 of an actuator was formed, and the concave 7 which the edge of 2nd internal electrode 3b exposed [the insulator 11] to the concave 7 which the edge of 1st internal electrode 3a exposed is filled up with the conductor 9.

[0021] Height h of the direction of a laminating of a concave 7 is set to about 1 / 5 - 1/3 of thickness t. [of a piezo electric crystal 2] Height h of the direction of a laminating of a concave 7 this in being larger than one third of thickness t of a piezo electric crystal 2 It is because there is risk of the thickness of the remaining piezo electric crystals 2 from which height h of a concave 7 stops having materialized as a slot in one half of thickness t of a piezo electric crystal 2, and the concave 7 was removed 1/2 or less becoming thin, and it becoming impossible to maintain reinforcement, and damaging in the handling at the time of processing. Moreover, it is for height h of a concave 7 to become [height h of a concave 7] extremely small in being smaller than one fifth of thickness t of a piezo electric crystal 2, and for processing to become difficult or to become easy to produce the short shot of a conductor 9 and an insulator 11. A cross section may be a circle configuration although, as for the configuration of a concave 7, the cross section is made into the shape of a square.

[0022] conductors, such as an alloy with which a conductor 9 makes Ag a subject, and an alloy which makes Cu a subject, -- it consists of a metallic material, is filled up in a concave 7 by screen-stencil, dipping, etc. after formation of a concave 7, and is obtained by calcinating at about 600 degrees C - 900 degrees C.
[0023] Moreover, an insulator 11 consists of insulating ingredients, such as glass, an epoxy resin, polyimide resin, polyamidoimide resin, and silicone rubber, and is obtained by filling up with and hardening an insulating ingredient in a concave 7. In addition, the quality of the material of low Young's modulus of an insulator 11, for example, silicone rubber etc., is desirable. This is because there is a possibility of exfoliation being produced in the interface of an insulator 11 and a piezo electric crystal 2 by expanding at the time of driving as an electrostrictive actuator, it becoming impossible to take insulation, and resulting in destruction, or a crack arising in a piezo electric crystal 2, and resulting in destruction when filled up with the quality of the material of high Young's modulus.
[0024] Here, after the sequence of formation of the conductor 9 with which it fills up in a concave 7, and an insulator 11 forms a concave 7 in the body 1 of an actuator which really calcinated and was acquired and fills up with and calcinates a conductor 9 alternately in this concave 7, it is desirable to be filled up with an insulator 11 in the remaining concaves 7.
[0025] Moreover, a conductor 9 can be formed even if it uses polyimide resin. In this case, it is not necessary to take into consideration especially the sequence of formation of a conductor 9 and an insulator 11. The polyimide resin used as a conductor 9 is resin of difficulty solubility which does not dissolve other than concentrated sulfuric acid. Therefore, the poly AMMIKU acid which is the precursor of polyimide is dissolved in a suitable solvent, for example, a N-methyl-2-pyrrolidone (NMP), a tetrahydrofuran (THF), etc., and it considers as the shape of a varnish, and electric conduction material is mixed and kneaded on this varnish with the volume fraction considered as a wish, and it is made the shape of a paste. It is filled up with this paste in a concave 7, and a conductor 9 is formed by making it harden at 400 degrees C from a room temperature.
[0026] In addition, it is desirable to use kneading machines, such as 3 roller mills, in the case of kneading. Moreover, it is desirable to use the metal powder with comparatively low volume resistivity of the 6-9th groups of the periodic table, such as nickel, silver, platinum, and gold, especially as electric conduction material into polyimide resin.
[0027] And in this invention, in a conductor 9, the end section of the connection conductive member 15 is laid underground, and the other end of this connection conductive member 15 is joined to the external electrodes 6a and 6b. A conductor 9 and the connection conductive member 15 are mechanically [electrically and] connectable by immobilization of the connection conductive member 15 into a conductor 9 filling up a concave with a conductor ingredient by screen-stencil, dipping, etc. after formation of a concave, and inserting the connection conductive member 15 in the conductor ingredient in a concave, for example, stiffening a conductor ingredient at room temperature -400 degree C.
[0028] The external electrodes 6a and 6b consist of a metallic thin plate 16 and electroconductive glue 17, the metallic thin plate 16 is laid underground into electroconductive glue 17, a metallic thin plate 16 is in the condition which contacted the connection conductive member 15, it fixes by carrying out low attachment or welding, and, thereby, the external electrodes 6a and 6b are joined to the body 1 of an actuator. Moreover, the external electrodes 6a and 6b are joined to the body 1 of an actuator also by electroconductive glue 17.
[0029] Although a metallic thin plate 16 and the connection conductive member 15 may have conductivity, and which metal is sufficient as long as processing is possible, it is desirable to be preferably formed with the metal which has high Young's modulus, such as stainless steel (alloy containing nickel and Fe), a nickel-Fe alloy, and a nickel-Fe-Co alloy. This is because control of the plasmotomy of a metallic thin plate 16 or a connection conductive member is attained in order to maintain sufficient reinforcement to the stress generated when stress acted on the external electrodes 6a and 6b by telescopic motion of an electrostrictive actuator by using the alloy which has the high Young's modulus which makes nickel and Fe a subject.
[0030] Although there are polyimide resin, conductive silicone rubber, etc. containing the electric

conduction material with comparatively small volume resistivity of the 6-9th groups of the periodic table, such as nickel, silver, platinum, and gold, as electroconductive glue 17 which constitutes the external electrodes 6a and 6b, it is not limited to this.

[0031] Moreover, to the both-ends side of the direction of a laminating of the body 1 of an actuator, the laminating of the inert segment 19 for holding the body 1 of an actuator mechanically and transmitting the power to generate to the exterior is carried out, and it is joined. Furthermore, although not illustrated, the whole side face of the body 1 of an actuator including the outside of the external electrodes 6a and 6b is covered with pre-insulation material, such as silicone rubber, thereby, penetration of the moisture from the outside can be prevented, generating of an internal electrode and external inter-electrode electromigration is controlled, and the dependability of electrode connection can be secured.

[0032] The laminating mold electrostrictive actuator constituted as mentioned above is manufactured according to the following processes. First, the slurry which mixed the temporary-quenching powder of piezo electric crystal ceramics, such as titanic-acid lead zirconate Pb(Zr, Ti) O3, the binder which consists of an organic giant molecule, and the plasticizer is produced, and a ceramic green sheet with a thickness of 100-200 micrometers is produced by the slip casting method.

[0033] The conductive paste which uses as a principal component the silver-palladium which serves as internal electrodes 3a and 3b at one side of this green sheet is printed in thickness of 1-10 micrometers with screen printing. After drying this conductive paste, only predetermined number of sheets carries out the laminating of two or more green sheets with which the conductive paste was applied, and the laminating of the green sheet with which the conductive paste is not applied to the both ends of the direction of a laminating of this layered product is carried out.

[0034] Next, it pressurizes heating this layered product at 50-200 degrees C, and a layered product is unified. After the unified layered product is cut by predetermined magnitude, a debinder is performed at 400-800 degrees C for 5 to 40 hours, and it is calcinated at 900-1200 degrees C for 2 to 5 hours, and acquires the body 1 of an actuator which has an inert segment 19 in a both-ends side. The edge of internal electrodes 3a and 3b is exposed to the side face of this body 1 of an actuator.

[0035] Then, the body 1 of an actuator is set to a fixture, and the side face of the body 1 of an actuator is processed using a surface grinder etc. until it becomes a predetermined configuration.

[0036] In two side faces of the body 1 of an actuator which counter Then, internal electrode 3a, The concave 7 whose height h of a depth of 100-500 micrometers and the direction of a laminating is 20-50 micrometers about the part which 3b edge exposed is formed. After being alternately filled up with electroconductive glue, such as Ag or nickel polyimide, in this concave 7, the end section of the connection conductive member 15 is inserted in this, heat hardening of the electroconductive glue is carried out at room temperature -400 degree C, and electric and mechanical connection of a conductor 9 and the connection conductive member 15 is made.

[0037] And this concave 7 is filled up with the insulators 11, such as silicone rubber. At this time, a conductor 9 and the connection conductive member 15 need to be made not to be covered by the insulator 11. Then, the welding technique, such as spot welding and ultrasonic welding, or technique, such as soldering, carry out junction immobilization of the other end of the connection conductive member 15, and the metallic thin plate 16 of the external electrodes 6a and 6b.

[0038] Then, while applying between the body 1 of an actuator, and metallic thin plates 16, and to its perimeter and evaporating a solvent in room temperature -400 degree C air or nitrogen-gas-atmosphere mind so that the external electrodes 6a and 6b may be formed for electroconductive glue 17, the external electrodes 6a and 6b can be formed in the side face of the body 1 of an actuator by making a hardening reaction cause.

[0039] then -- although not illustrated -- a positive electrode -- business -- an external electrode and a negative electrode -- business -- lead wire is connected to an external electrode and cladding materials, such as silicone rubber, are covered with approaches, such as dipping, around an actuator. Furthermore, about 1-3kV [/mm] polarization electric field are impressed to a positive electrode and a negative electrode, polarization processing to a piezo electric crystal 2 is performed, and the laminating mold electrostrictive actuator of this invention is obtained.

[0040] In addition, the laminating mold electrostrictive actuator of this invention has the desirable shape of the ease of cutting to the square pole, although the square pole, a hexagonal prism, a cylinder, etc. may be what kind of prisms.
[0041] Moreover, although the above-mentioned example explained the example which formed the external electrodes 6a and 6b from electroconductive glue 17 and a metallic thin plate 16, a metal mesh may be used for this invention instead of a metallic thin plate. In this case, stress is effectively absorbable.
[0042] Drawing 3 shows the fuel injection equipment of this invention, and the sign 51 shows the stowage container in drawing. A nozzle 53 is formed in the end of this stowage container 51, and the needle valve 55 which can open and close a nozzle 53 is held in the stowage container 51.
[0043] The fuel path 57 is established in a nozzle 53 possible [a free passage], this fuel path 57 is connected with an external fuel source, and the fuel is always supplied to the fuel path 57 with fixed high pressure. Therefore, if a needle valve 55 opens a nozzle 53, it is formed so that the fuel currently supplied to the fuel path 57 may blow off in the combustion chamber which an internal combustion engine does not illustrate with fixed high pressure.
[0044] Moreover, the diameter is large and the upper limit section of a needle valve 55 serves as the cylinder 59 and the piston 61 on which it can be slid which were formed in the stowage container 51. And the above-mentioned electrostrictive actuator 63 is contained in the stowage container 51.
[0045] In such a fuel injection equipment, if an electrical potential difference is impressed to an electrostrictive actuator 63 and it develops, a piston 61 will be pressed, a needle valve 55 will blockade a nozzle 53, and supply of a fuel will be suspended. Moreover, if impression of an electrical potential difference is stopped, an electrostrictive actuator 63 will contract, the pan spring 65 pushes back a piston 61, a nozzle 53 is open for free passage with the fuel path 57, and injection of a fuel is performed.
[0046]
[Example] Printing formation of the internal electrode paste which uses Ag/Pd as a principal component at a green sheet with a thickness of 200 micrometers which uses PZT as a principal component was carried out by the thickness of 5 micrometers. The 300-sheet laminating of the green sheet with which the internal electrode paste was applied was carried out, and after this, the laminating of the green sheet with which the internal electrode paste is not applied to both sides was carried out, and heating junction was carried out and it unified.
[0047] This layered product was cut so that it might be set to 10mm by 10mm, and the debinder was performed in 700-800 degrees C of maximum temperatures, and 20 - 30 hours. Then, baking was performed for 3 to 5 hours at 900 degrees C - 1100 degrees C of maximum temperatures, and the body 1 of an actuator which has the inactive object 19 was acquired.
[0048] Next, the acquired body 1 of an actuator was set to the fixture, and surface grinding of the side face of the body 1 of an actuator was performed. Then, the part (a piezo-electric plate and internal electrode) which the internal electrodes 3a and 3b of the side face of the body 1 of an actuator have exposed was excised by cut sew in the configuration shown in drawing 2 , and the concave 7 whose height h of 500 micrometers and the direction of a laminating is 50 micrometers was formed in the depth direction.
[0049] Then, after having been filled up by having used the dispenser for the concave 7 of the body 1 of an actuator, and having poured silver polyimide electroconductive glue into it, inserting a covar foil with the thickness of 30 micrometers, a width of face [of 1mm], and a die length of 2mm, or silver foil in that interior and carrying out predrying for 10 minutes at 120 degrees C, 220 degrees C and hardening of 1 hour were performed, and in the conductor, the end section of the connection conductive member 15 was laid underground, and it fixed.
[0050] Next, silicone rubber was applied in ordinary temperature in the concave 7 with which a conductor 9 is not filled up, and it was filled up by vacuum degassing. Then, the metallic thin plate 16 which consists of a covar foil or silver has been arranged on the side face of the body 1 of an actuator, and the other end and the metallic thin plate 16 of the connection conductive member 15 were joined by ultrasonic welding.

[0051] Then, the electroconductive glue which consists of silver polyimide was applied between the body 1 of an actuator, and metallic thin plates 16, and to its perimeter, and the 220-degree C drying furnace performed hardening adhesion. Then, lead wire was soldered to the metallic thin plate, external covering was performed in silicone rubber, 2.5kV [/mm] direct-current electric field were impressed to the positive electrode and the negative electrode for 30 minutes, polarization processing was performed, and the laminating mold electrostrictive actuator was obtained.
[0052] And when stress 20MPa was impressed to the laminating electrostrictive actuator and the amount of displacement was checked in driver voltage 200V, the amount of displacement of 40 micrometers was obtained for each sample. Next, stress 20MPa was impressed, the pulse alternating electric field of 0-200V was impressed on the frequency of 60Hz, the continuation drive trial was performed, and exfoliation and an open circuit of an external electrode and an internal electrode were checked. The result is shown in Table 1.
[0053] While being filled up only with an insulator in a concave and insulating with one internal electrode as a comparison Expose the edge of the internal electrode of another side on the body of an actuator, and the laminating (edge of internal electrode adheres with electroconductive glue) mold electrostrictive actuator which connected the external electrode which covered the metallic thin plate with Ag polyimide conductive resin to this is produced. When stress 20MPa was impressed to this and the amount of displacement was checked in driver voltage 200V, in early evaluation, the amount of displacement of 40 micrometers was shown like the above-mentioned sample. Moreover, the continuation drive trial was performed similarly and the result was also indicated to Table 1.
[0054]
[Table 1]

試料 No.	接続導電部材 材質	金属薄板 材質	駆動サイクル 外部電極10^7回 剥離、断線有無	外部電極破損状況
1	コバール	コバール	無	1×10^9 異常無し
2	コバール	Ag	無	8×10^7 金属薄板損傷
3	Ag	コバール	無	1×10^8 接続導電部材損傷
4	Ag	Ag	無	3×10^7 金属薄板、接続部材損傷
* 5	——	コバール	有	5×10^6 外部電極の剥離

＊印は本発明の範囲外の試料を示す。

[0055] From this table 1, exfoliation or an open circuit of an external electrode and an internal electrode did not occur in 107 or less cycle of drive cycles at the laminating mold electrostrictive actuator of this invention which joined the metallic thin plate to the connection conductive member. And neither exfoliation of an external electrode and an internal electrode nor an open circuit of an external electrode generated even the 109 cycle drive cycle by making the quality of the material of a connection conductive member and a metallic thin plate into covar with high Young's modulus.
[0056] Moreover, the concave was formed by turns and exfoliation of an external electrode and an internal electrode occurred in the 5**105 cycles drive cycle in the conventional example of a comparison filled up only with the insulator in this concave.
[0057]

[Effect of the Invention] In the laminating mold electrostrictive actuator of this invention, an internal electrode edge and an external electrode are certainly connectable by joining firmly the connection conductive member under which the end section was laid, and an external electrode by welding, soldering, etc. to the conductor in the concave formed in the side face of the body of an actuator. A laminating mold electrostrictive actuator with the high dependability equipped with high endurance can be offered without disconnecting exfoliation of an external electrode and an internal electrode and an external electrode, when carrying out a long-term continuation drive by high impression electric field by this at high speed.

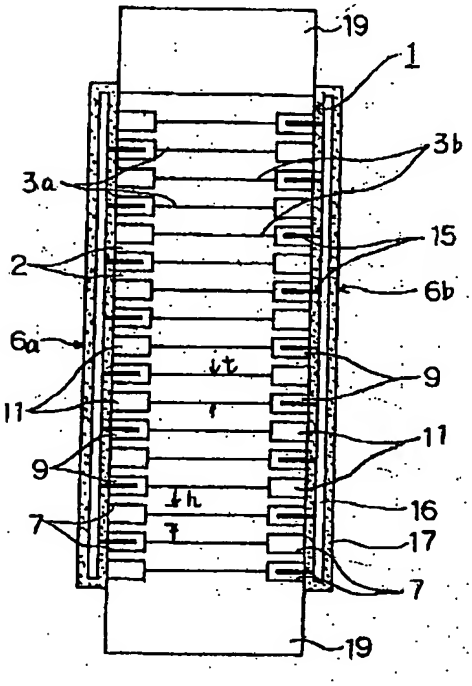
[Translation done.]

* NOTICES *

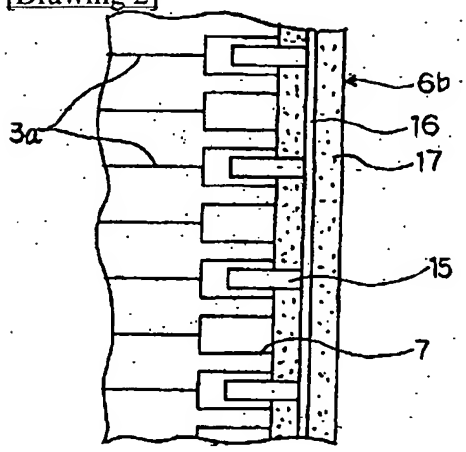
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

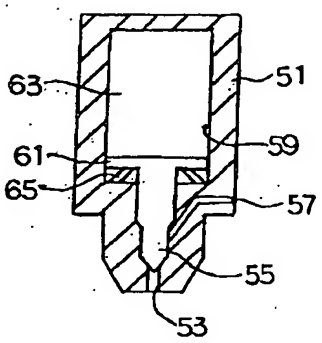
[Drawing 1]



[Drawing 2]



[Drawing 3]



[Translation done.]